LUBRICATION

A Technical Publication Devoted to the Selection and Use of Lubricants

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Contracting Machinery

The Value of Selective Lubrication

"DIGGING IN" was a necessary procedure among our cave-dwelling ancestors if they desired to escape the sabre-tooth tiger and live to die a natural death,—at least at the hands of their own kind. Later, as the population of the world increased, and family ties were more firmly knit, respect developed the practice of digging for burial purposes. The Egyptians excavated and cut rocks for the erection of monuments: viz., the pyramids; the North American Indian dug earth for burial mounds.

The late war, however, taught us the value of practical "digging-in" most forcibly, for it meant self-preservation, at least temporarily. It was all a rather crude procedure, on the other hand, performed by manual labor, just, as our ancestors had done it, with painful slowness. No wonder then that peace-time hastened the further development of mechanical means of excavation and the handling of bulk materials. As practiced today, this modern method of mass production "digging-in" is not done for self-preservation reasons, nor in the performance of religious rites; it is, however, very definitely a matter of monument erection. The latter, in the form of endless ribbons of high-speed highways across the country, of diverted waterways, of methods of flood control, may perhaps, be as noteworthy to our descendants as the pyramids, and certainly of more tangible value.

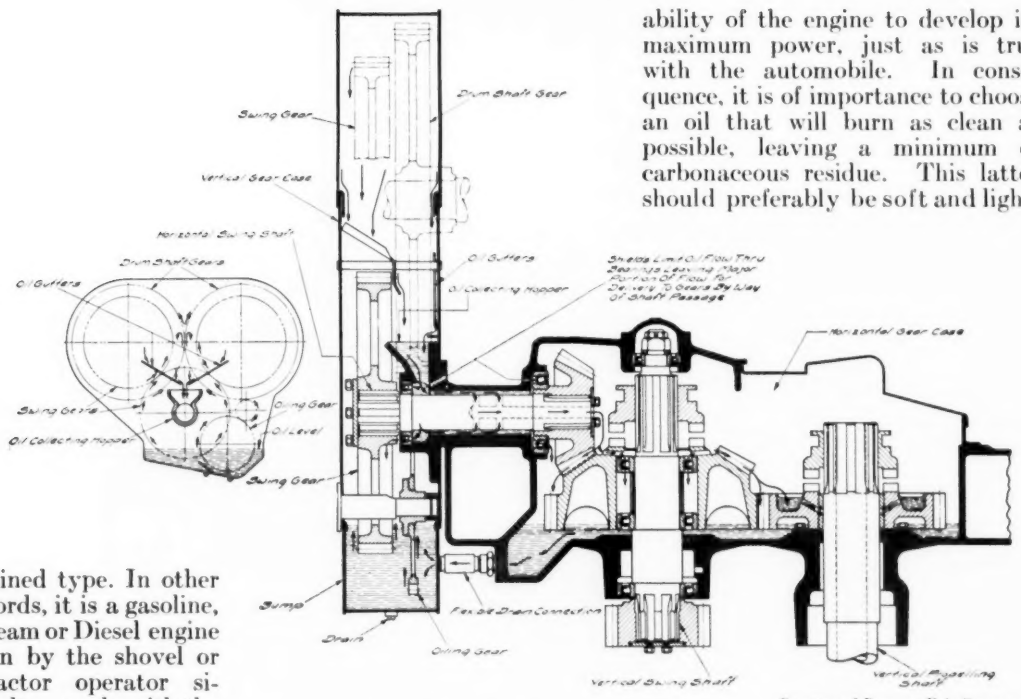
The recent floods and the necessity of moving huge quantities of earth and rock in a very short time emphasize the true value of the power shovel, drag line and trenching machine; there is no doubt but that without them the ability to withhold the Mississippi might have been well-nigh impossible. Now that that has been accomplished these machines along with the concrete mixer will most certainly play a very important part in building higher and more permanent levees, in constructing or repairing roadways in the flood areas, and elsewhere, in furthering our national rehabilitation program.

Materials handling in bulk requires coordination of ideas with regard to machine maintenance and cost of supplies. The power shovel, drag-line or any other of the equipment used in this service is built for heavy-duty service; the mechanisms are costly and designed to work together with maximum efficiency. Obviously, they must receive the utmost protection. Design has provided for this in part, but another element—lubrication—must be maintained if we are to keep down wear and the cost of parts replacement.

THE POWER PLANT

The power plant must obviously be regarded as the most important part of any piece of contracting machinery. Gears may be noisy and wire rope not entirely safe; furthermore, bearings may have pounded out,—yet things will keep on running. Difficulties in the power plant, however, will usually cause cessation of operations, especially where lack of lubrication is concerned. The power plant in contracting operations is generally of the unit, self-con-

ability of the engine to develop its maximum power, just as is true with the automobile. In consequence, it is of importance to choose an oil that will burn as clean as possible, leaving a minimum of carbonaceous residue. This latter should preferably be soft and light, tained type. In other words, it is a gasoline, steam or Diesel engine run by the shovel or tractor operator simultaneously with the manipulations of the machine.



Courtesy of Bucyrus-Erie Company

Fig. 1—Lubrication diagram for a Bucyrus-Erie excavating machine, showing flood oil lubrication of gears and bearings for swing, propelling machinery and drum shaft gears on revolving frame. Diagram at left (reduced scale) shows view of gear case, with arrows indicating circulation of oil.

Internal Combustion Engine Requirements

The essential points which should be better understood in regard to the lubrication of a gasoline or Diesel engine include:

1. The operating conditions and results demanded of the engine.
2. The types of lubricating systems employed.
3. The service conditions to which lubricating oils may be subjected, and
4. The procedure to follow in selecting such oils.

In considering the operating conditions that may prevail, one is concerned with the several properties which an engine oil must possess to render it satisfactory. In other words we must develop the extent to which the oil will carbonize; the operating temperatures which may be prevalent, and the pour test of the oil or its ability to flow under relatively cold conditions; and the viscosity which the oil will possess under full load operation, for on this will depend the extent to which the engine cylinders and pistons will be properly lubricated.

Carbonization is one of the most evident indications of the unsuitability of an engine oil during operation. Carbon formations on valves, spark plugs, valve seats, around rings, and in the combustion chamber hamper the for thereby will its partial removal be possible via the exhaust.

In many cases, however, these so-called carbon formations will consist of other ingredients besides actual carbon. Especially is this true where the machine is operating under dirty conditions or in an atmosphere laden with abrasive dust. Unless some form of air cleaner is installed for the purpose of purifying the air for combustion, prior to its entry into the carburetor, a goodly percentage will pass into the engine and tend to increase and promote deposits to a marked extent. As a result an air cleaner is advisable, for its installation will usually insure of better engine performance.

The operating and atmospheric temperatures also are of moment, due to the extent to which the ready starting of the engine may be affected. In this connection, the pour test of the oil is an important characteristic, as it serves as an indication of the ability of the oil to flow under lower temperatures. Wherever these latter may drop below freezing, or to within the neighborhood of zero, it is very important to choose an oil of as low a pour test as possible, in order that practically immediate flow will occur to all bearings and cylinders upon starting of the engine. To a certain extent reduction of the original viscosity may aid in this respect, although there will be a possi-

bility that the ultimate operating viscosity may be rather low.

In connection with viscosity, it is important to note that very frequently the engine in heavy duty materials handling service may function at higher temperatures than the average automotive engine. While this will improve the combustion of the fuel to some extent, it will also tend to reduce the operating viscosity. On the other hand, higher engine temperatures with more complete combustion will reduce the possibility of dilution or the thinning out of the lubricating oil. As a result, there will be but relatively little chance of viscosity reduction by temperature alone being a detriment provided the lubricating system delivers a sufficient amount of oil to all the contact parts. Where larger sized engines are involved, or where rings may have become worn, a certain increase in normal viscosity will be advisable.

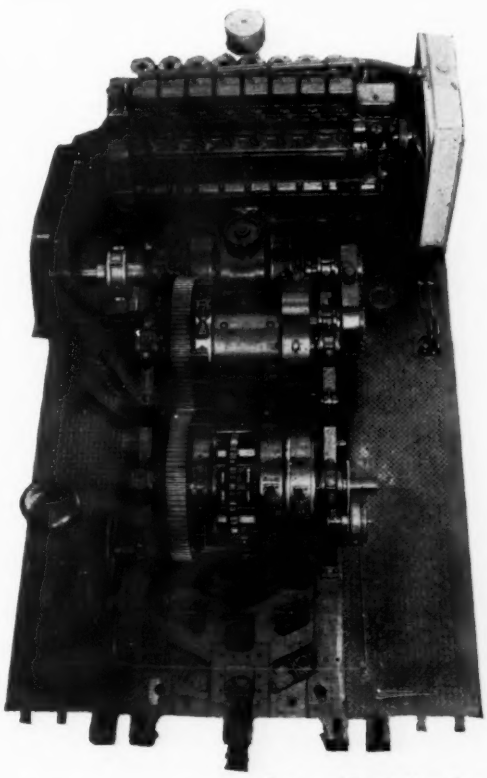
Power and Fuel Economy

Shovel, dragline or tractor engines lubricated with oils selected with due regard to the operating conditions will be more nearly capable of developing maximum power with the greatest economy of fuel, and the occurrence of the least amount of dilution.

Maximum power becomes possible only where there is maximum compression. While this is chiefly affected by carbon deposits and uneven seating of the valves we must not overlook the movement of the piston rings in their respective grooves, and the extent to which they maintain the requisite seal between the cylinder walls and pistons to prevent "blow-by."

The purpose of these rings is to take care of the more or less variable clearance which practically always exists between the above parts. As a result, these rings must be capable of as free movement as possible. This can only be attained by keeping them free from carbon or gum deposits. Under such conditions, regardless of the age of the engine, or the variation in clearances, if the rings are not abnormally worn, where the oil film is of the requisite body, compression losses will be practically negligible. On the other hand, rings which have worn unevenly, or become stuck due to carbon or gum formations will tend to reduce the power capacity of the engine. In addition, dilution will occur and general operating efficiency will fall off materially. Under such conditions the substitution of a heavier oil will only serve as a temporary expedient.

There is also a definite relation between maximum power and fuel economy. Obviously the better the compression the less will be the chance of "blow-by", provided lubrication is effective and the piston rings are not fouled with deposits. The effect that "blow-by" will have on the engine is noteworthy. In the first place it will in all probability reduce, or, in many cases wash off the lubricating film from the cylinder walls. The direct result may easily



Courtesy of Harnischfeger Corp.

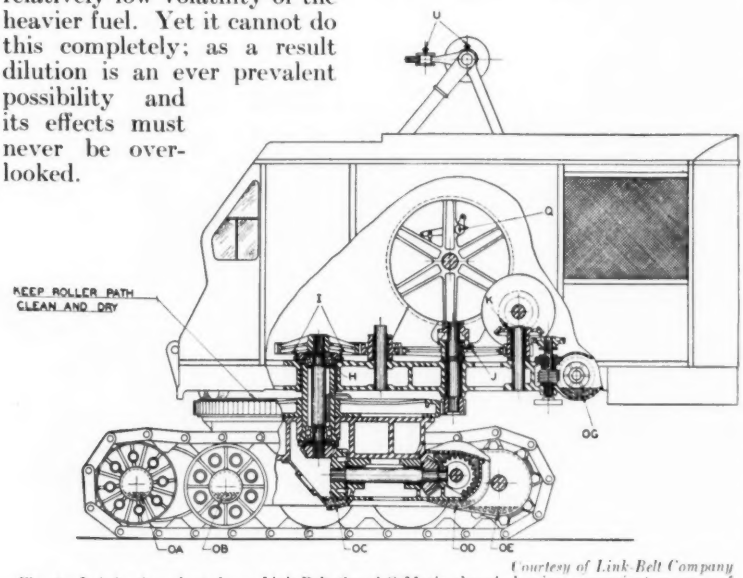
Fig. 2—Top view of a Harnischfeger machine showing mounting of engine with respect to hoisting mechanisms, and method of power transmission.

be scoring of the latter due to lack of lubrication, especially if dilution of the oil in the crankcase has occurred to an excess. Furthermore, this will lead to the consumption of more power in overcoming friction between the wearing parts of the engine. The thinner the oil by virtue of dilution with fuel, the greater, also, will be the possibility of dangerous metal-to-metal contact in the bearing elements.

Crankcase dilution of the lubricating oil in any heavy duty engine using low-volatility fuels will be more prevalent than in the average automotive type engine which functions on gasoline. This is because light fuel oils or kerosene vaporize less completely than gasoline; in consequence the heavier unvaporized parts are ready and capable of exerting a solvent action upon the oil film on the cylinder walls to possibly pass the rings under favorable conditions.

Of course, a Diesel or kerosene engine will

generally function at somewhat higher temperatures than a gasoline engine. This fact will naturally tend to aid in the attainment of more complete vaporization and offset the relatively low volatility of the heavier fuel. Yet it cannot do this completely; as a result dilution is an ever prevalent possibility and its effects must never be overlooked.



Courtesy of Link-Belt Company

Fig. 3—Lubrication chart for a Link-Belt Speed-O-Matic shovel showing convenient manner of locating grease fittings. Points marked OA to OG inclusive show parts designed for extreme pressure lubricant.

Relation of the Lubricating System

Fortunately, improvements in lubricating systems are also effective in preventing dilution, provided they are adaptable to the type of engine and capable of delivering the oil in conformation with the requirements, whatever the speed or temperature involved. According to design, the mechanical force feed oiler, the full pressure system or the circulating splash method of lubrication is used; or, in lieu of any of these direct methods, certain combinations serving bearings and cylinder walls separately are applicable as in Diesel practice.

The Mechanical Lubricator

Mechanical force feed lubrication by means of an externally attached oiler capable of feeding the oil drop by drop to the respective wearing surfaces is a practical necessity in many Diesel operations. As a means of cylinder lubrication it virtually eliminates the objectionable features of crankcase dilution. As a result, provided the lubricator is capable of furnishing the necessary amount of oil to the engine, and provided the oil is of the proper characteristics, the maximum of power and fuel economy should be developed.

In detail, mechanical force feed lubrication involves the delivery of oil by means of individual pumps and oil piping to each respective part requiring lubrication. In this regard it is very much akin to the method of mechanical force feed lubrication so extensively used on the reciprocating steam engine, or air compressor. Fresh oil is continually supplied in a predetermined amount to all parts served by such a lubricator. Any one, in fact, can usually be fed with more or less oil as desired, by simply adjusting the lubricator accordingly. Nor, is there any chance for waste, inasmuch as the lubricator pumps are actuated by the engine, starting and stopping, therefore with the latter.

On the other hand, the mechanical force feed lubricator is an independent mechanism, being attached in some manner to the exterior of the engine. As a consequence the oil contained is usually more sensitive to temperature fluctuations than the oil in the crank case of a splash or pressure lubricated engine. This, of course, may be a detriment in cold weather, especially if abnormally low temperatures are encountered, or, if an oil of the requisite fluidity is not being used. In such cases trouble will be more apt to be encountered on the suction side of the pump, due to the sluggish condition of the oil. If the pumps are able to take this oil there should be little difficulty in delivering it to the respective bearings and cylinders of the engine for usually these pumps are capable of exerting sufficiently high pressures to overcome any resistance due to increased viscosity or congealment.

Self-contained Lubrication

In contrast to the mechanical force feed lubricator, oil circulating systems of the full pressure, splash or combination types, provide for the repeated usage of the oil. On first sight this is an apparent economy and an advantage over the above described method of using the oil but once as an engine lubricant, instead of discarding the residue or using it to oil gears, link pins or other exposed parts. On the other hand the matter of crankcase dilution is involved wherever circulating systems are employed, with the possible difficulties as already discussed. There are, of course, differences of opinion in regard to both methods.

The full pressure method is perhaps the most generally preferred in the power shovel or tractor engine by reason of the fact that it

insures the delivery of a liberal supply of oil to all wearing parts from the time the engine starts until it is shut down, irrespective of the speed. Furthermore, there is more washing action brought about by such oil in its passage through the bearings, to preclude any chance accumulation of foreign matter in the grooves or around the piston rings.

Regardless of the means of lubrication, however, any oil for such service should possess certain very definite requirements if it is to afford the necessary amount of lubrication with the most perfect seal, function properly in cold weather, resist the effects of high temperature and reduce both solid and fluid friction to a minimum.

The Advantages of Piston Sealing

Lubrication and seal are of importance, the one to prevent metal-to-metal contact, the other to prevent loss of compression and reduce crankcase dilution where a circulating system is involved. A measure of the lubricating value of an oil is the extent of freedom from scored cylinders, worn rings, burned out bearings, etc. Likewise a measure of the seal-forming ability is the extent to which the requisite compression and power of the engine are maintained.

Cold weather operation and the necessity for ample fluidity have already been mentioned. On many jobs this may not be an important factor. As a rule, however, it should be given due consideration for the more fluid the oil at low temperatures, the more assurance will there be that a chance cold spell will not entail the possibility of bearing trouble, or the necessity for renewing piston rings, etc. Where cold weather operation is more than just a possibility viscosity and pour test, therefore, become two of the paramount points of consideration when choosing the oil.

Relative to the effects of high temperature it is well to state that the oil should be capable of functioning in the engine without breakdown, loss in viscosity or burning to hard, adhesive carbon. These conditions would probably involve a decrease in the resultant amount of power, just as would the development of a high degree of internal friction between the particles of oil which constitute the lubricating film. Frequently an oil of apparently the right normal viscosity to resist the pressure existing at the several bearings involved might show altogether too high a free carbon content or frictional condition at the operating temperatures. These are difficult factors for the operator to ascertain, except over extended operation by careful observation.

In selecting any such oil he must know that it will maintain the requisite viscosity under operation, giving the maximum of lubrication and seal with the least amount of carbon, and that it will start or flow readily under his operating temperatures regardless of their range.

Courtesy of The Osgood Company

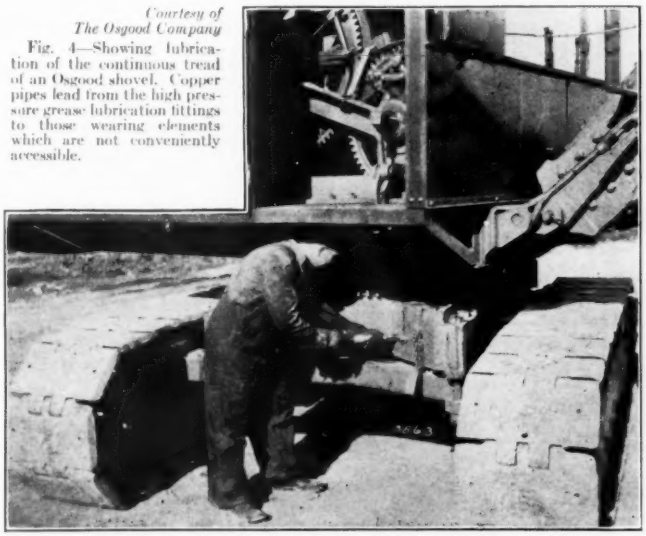


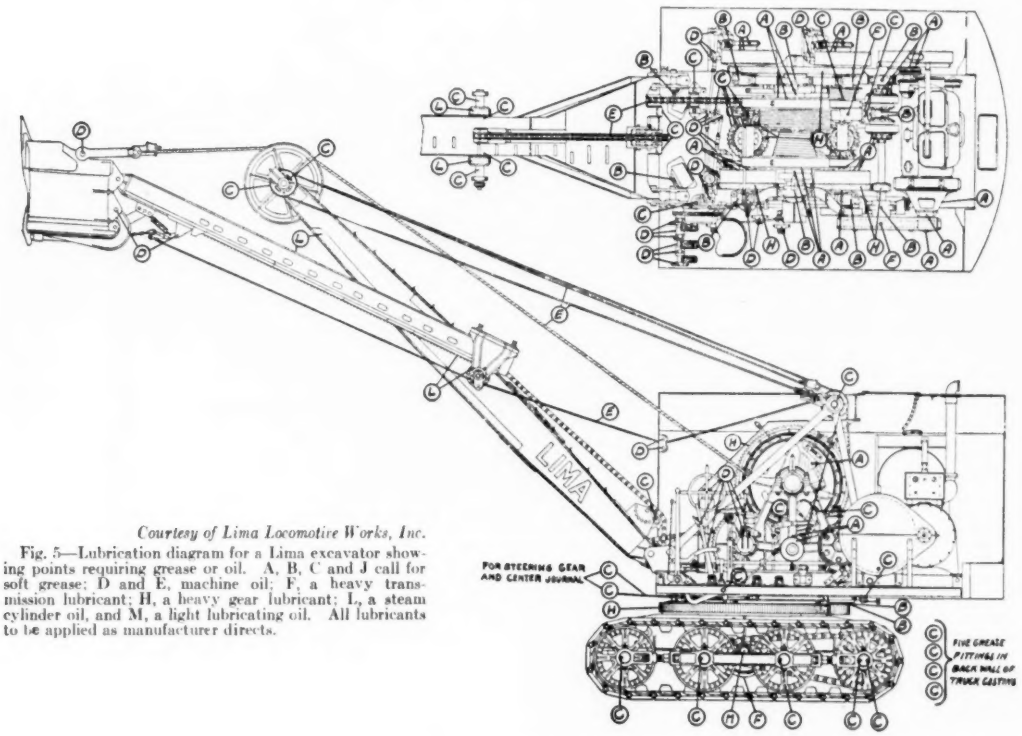
Fig. 4—Showing lubrication of the continuous tread of an Osgood shovel. Copper pipes lead from the high pressure grease lubrication fittings to those wearing elements which are not conveniently accessible.

THE AIR COMPRESSOR IN POWER GENERATION

Development of the gas-air or Diesel-air type of power plant also requires a study of the essentials of air compressor cylinder lubrication. In other words the compressor is part of of the power plant, compressed air being used instead of steam as the motive power for the auxiliary engines. Such a unit will normally involve a horizontal four-cylinder single stage compressor direct connected to a Diesel or gasoline engine. Heat is an important adjunct in such an assembly hence the absence of any provision for cooling the air after it has been compressed. Instead, the discharge is passed through a heat exchanger connected to the exhaust of the engine. The operator is, therefore, confronted with the problem of cylinder lubrication under comparatively severe conditions for the temperature at discharge will range in the neighborhood of 500 degrees Fahr., where compression is carried up to around 100 lbs. gauge.

All of which calls for the utmost care in selecting an oil for such service. In particular it must be capable of withstanding the high temperatures involved with the minimum of vaporization and carbon formation. This re-

quires very close fractionation in refining, and the use of specially selected crudes, for the finished product must not only lubricate effectively, but must resist decomposition when exposed to heated air; otherwise it might become a hazard due to the possibility of failure of those parts of the system where carbon and dirt deposits may have accumulated to restrict the flow of air and cause even higher temperatures to develop.



Courtesy of Lima Locomotive Works, Inc.

Fig. 5—Lubrication diagram for a Lima excavator showing points requiring grease or oil. A, B, C and J call for soft grease; D and E, machine oil; F, a heavy transmission lubricant; H, a heavy gear lubricant; L, a steam cylinder oil, and M, a light lubricating oil. All lubricants to be applied as manufacturer directs.

So we are definitely interested in the viscosity, as the criterion of film strength or body, the flash point as an indication of vaporization and the type of carbon which may be formed.

Viscosity Denotes Relative Fluidity

Viscosity is quite as important in the power shovel air compressor as it is in the internal combustion engine, for very much the same operating conditions are prevalent, with the exception of crankcase dilution. There is, of course, no relation between viscosity and chemical stability although both are developed by carefully planned refinery procedure. The one is a purely physical characteristic, the other chemical, and indicative of resistance to breakdown.

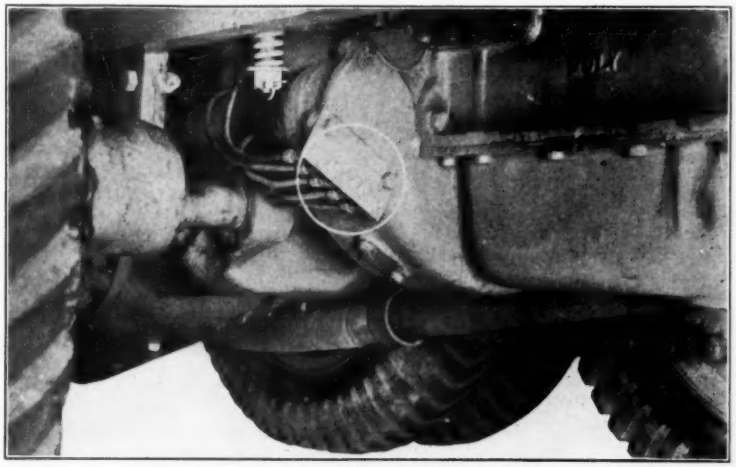
In shovel operations or the handling of portable air compressors, viscosity is indicative of relative fluidity. In service, change in relative fluidity will occur with change in temperature, higher temperatures causing oils to become more fluid. Since cylinder wall temperatures will vary, the operating viscosity of the oil must be given careful consideration; the degree of piston seal attainable can be judged by the indicated viscosity of the oil at the operating temperature. This will in turn affect the efficiency of compression.

Where an oil is too light in body or too low in viscosity at the operating temperatures in the cylinder, it might easily work past the piston rings and fail to maintain a suitable seal. In turn, too heavy an oil would tend to develop gummy matter which might cause the piston rings to stick. An air compressor oil should consequently have sufficient viscosity to sustain the weight of the moving parts, and form a proper seal between the piston rings and cylinder walls; on the other hand, it should never be so heavy as to atomize with difficulty or collect any dust that may be present in the air to generate deposits. This is especially likely to happen when more oil has been used than just sufficient to lubricate the wearing surfaces, or where the air is not properly cleaned.

In considering the flash point, it should be regarded as an indication of vaporization rather than as a measure of oil consumption or as related to mechanical difficulties. With regard to the latter, it is safe to say that the relative merits of oils of either high or low flash

are usually over-stressed; high flash products may cause more carbon deposits, while those of lower flash have been at various times associated with the possibility of explosion. Observation of the conditions under which some so-called compressor explosions have occurred, however, has led to the opinion that the latter are more generally of mechanical nature and due to direct failure of some parts of the system because of over-heating as brought about by deposits.

If any brief is to be held it is, therefore, in favor of the lower flash type of oil which will vaporize cleanly after having served its purpose, leaving the minimum of carbonaceous or gummy residue. In this connection, it is well to remember that petroleum oils are all composite hydrocarbon mixtures, so different portions will be distilled off or vaporized at different temperatures, in amounts dependent upon how closely the original crude has been fractionated. Obviously, if this process is carried out between narrow temperature ranges, the resultant cuts will contain a greater percentage of hydrocarbons of about the same volatility, so that loss by vaporization after these cuts are called upon to function as lubricants will be markedly reduced.



Courtesy of The Austin-Western Road Machinery Co.

Fig. 6—An Austin-Western Motor Grader showing close-up view under the power plant, and bank of lubricator fittings (circled) which make for easy lubrication of the internal mechanisms.

STEAM CYLINDERS

In determination of the lubrication requirements of steam cylinders, consideration must be given to the existing operating conditions. These include steam pressure, location of cylinder oil inlet, type of lubricator, and moisture content of the steam. In average power shovel service steam pressures will range around 150 pounds pressure; normally it will have quite an extensive moisture content, even though the steam is taken from the highest part of the boiler. Furthermore, line condensation will be high between the boiler and engines, with a corresponding decrease in pressure, due to the fact that steam pipes are often not thoroughly covered, and the engines are frequently subject to intermittent operation. This will lead to a considerable accumulation of water above the throttle valves at each period of shut-down, depending in amount upon the length of time they have been stopped. Where the cylinders are not covered with a tenacious film of properly compounded steam cylinder oil, the admission of these slugs of water will tend to wash the lubricant from the wearing surfaces, and for the next few strokes insufficient lubrication will be possible and scoring and abnormal wear may occur.

Constant repetition of this will produce compression losses and lead to inefficient operation of the entire machine due to steam leakage past the piston rings. Groaning of the engines or rattling of the valves on their seats will be audible indication of faulty lubrication.

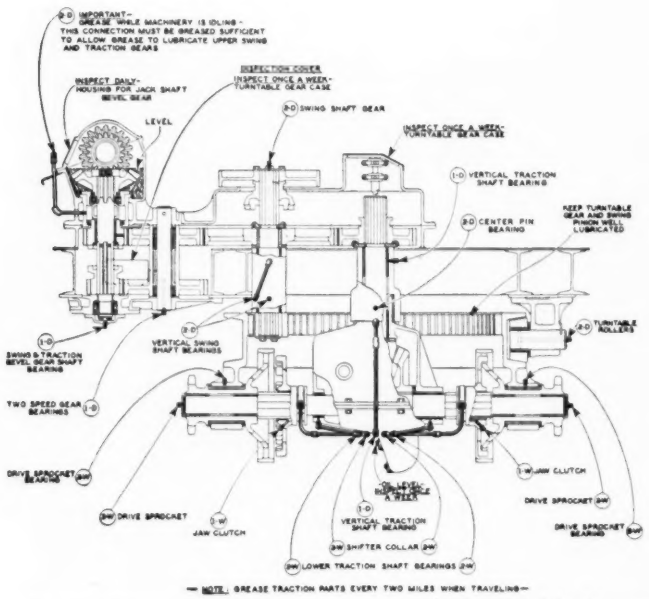
Point of Lubricant Application

Steam cylinder oils should be introduced into the steam-line some six to eight feet above or preceding the throttle valve wherever practicable. This will allow time for atomization to be completed by the time the lubricated steam reaches the throttle valve; this insures lubrication of this element along with the engine valves and cylinders.

Where oil is introduced too close to the throttle valve or cylinder, complete atomization may not take place; if too far away there will be a possibility of the oil particles being thrown out of the steam line, to subsequently flow in liquid form to the valve chest. This condensation of lubricant may be quite considerable if there are any bends or other pipe fittings located between the lubricator and the valve chest. It is not conducive to effective lubrication.

Steam cylinder oils should be delivered by a positive feed lubricator, preferably of the force feed type, via suitable atomizers. Hydrostatic lubricators would be practicable were the engines to operate continually, but the usual in-

termittent service involved would either require constant closing and opening by the fireman, or else a waste of oil would follow if the lubricators were left in service while the engines are stopped.


2-D IMPORTANT- GREASE WHILE MACHINERY IS IDLING - THIS CONNECTION MUST BE GREASED SUFFICIENT TO ALLOW GREASE TO LUBRICATE UPPER SWING AND TRACTION GEARS
INSPECT DAILY- HOUSING FOR JACK SHAFT BEVEL GEAR
INSPECTION COVER
INSPECT ONCE A WEEK- TURNTABLE GEAR CASE
LEVEL
2-D SWING SHAFT GEAR
INSPECT ONCE A WEEK- TURNTABLE GEAR CASE
1-D VERTICAL TRACTION SHAFT BEARING
KEEP TURNTABLE GEAR AND SWING PINION WELL LUBRICATED
2-D CENTER PIN BEARING
2-D TURNTABLE ROLLERS
2-D VERTICAL SWING SHAFT BEARINGS
1-D SWING & TRACTION BEVEL GEAR SHAFT BEARING
TWO SPEED GEAR BEARINGS 1-D
DRIVE SPROCKET BEARING 2-W
2-W JAW CLUTCH
DRIVE SPROCKET 2-W
DRIVE SPROCKET 2-W
1-W JAW CLUTCH
1-D VERTICAL TRACTION SHAFT BEARING
2-W SHIFTER COLLAR 2-W
2-W LOWER TRACTION SHAFT BEARINGS 2-W
NOTE: GREASE TRACTION PARTS EVERY TWO MILES WHEN TRAVELING

Courtesy of Koehring Company

Fig. 7—Lubrication chart for a Koehring shovel-crane. Points marked 2-D require grease twice a day; those marked 1-D require grease once a day. 2-W are greased twice a week; 1-W once a week, and 1-M are greased once every month.

Location of the crowding engine on the boom in certain types of these machines frequently presents a problem in lubricant application. The oil line often enters the steam pipe at a considerable distance from the throttle, with the result that in event of steam leaks at the ball or swing joint there will be considerable loss of oil with possibility of insufficient lubrication.

Type of Lubricants

Average requirements can be met most effectively by using steam cylinder oils of comparatively heavy body, and particularly adhesive characteristics in order to insure the maintenance of a lubricating film which will resist the wearing or scraping effects of the average valve and piston, and washing off by the steam itself. This will be assured by using a medium viscosity, highly adhesive, steam refined cylinder stock which contains a sufficient amount of high grade animal or fixed oil to promote the formation of a tenacious film of emulsified lubricant, which will adequately resist the washing action of any water that may be present.

Viscosity or body is attainable by suitable refining; adhesiveness by judicious treatment of the cylinder stock by the addition of certain fixed or fatty animal oils. As a general rule, it will be essential to use an oil having a viscosity range of between approximately 100 and 160 seconds Saybolt at 210 degrees Fahr., according to the steam pressure and temperature involved, the type of steam valves and the means of application. The latter, in turn, requires study of the construction of the atomizer and the type of lubricator.

A suitable atomizer installed in the steam line affords a most efficient way of getting the lubricating oil to all desired points inside of the valve chambers and cylinders by using the steam as a carrier. By thus dividing the oil into minute globules and intimately mixing it with the steam, only a very small quantity is required. The degree of success in atomization of the oil will control both the efficiency of lubrication of the parts and the quantity necessary.

ELECTRIC MOTORS

The electric motor is adaptable to power shovel, crane and drag-line operation wherever power resources are available. Although not as extensively used as the internal combustion engine, or steam-engine, its practicability demands consideration from a lubrication point of view. Normally this will only involve bearings, or perhaps the geared motor. There are many interesting installations of this nature lined up with the extension of various public works programs. Thereon, motor lubrication must be positive and dependable for, obviously, any failure may become serious if so much wear occurs as to allow the rotor to come in contact with the pole pieces and cause burn-outs and shut-down of the machine. So the electric motor is, perhaps, the most delicate mechanism involved in construction equipment. Frequently, however, it is given but little consideration, regardless of the duty imposed by temperature fluctuation, dust, dirt, water, or other contaminating foreign matter. Such conditions may easily cause a severe strain on motor bearings, by virtue of their design and construction, and the normally limited capacity of their lubricating systems.

Electric motors, as designed for this service may be equipped with ring oiled bearings, or with anti-friction bearings of the ball or roller type. Where the ring oiler is employed oil must always be used as the lubricant. Normally, a straight mineral, highly refined product

of from 175 to 300 seconds Saybolt at 100 degrees Fahr., will suffice.

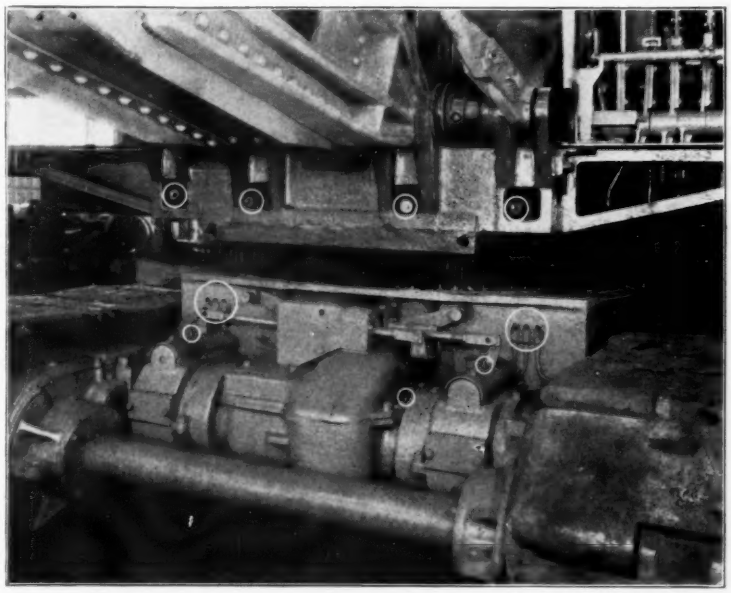
The necessity for low pour test is obvious, especially where the machine is to be started and operated at comparatively low temperatures, since the average well ventilated ring oiled bearing will not develop much heat. As a result, every care must be observed in the initial selection of the oil, to insure against congealment or sluggish flow. Otherwise, damage to the bearings might occur, due to failure of the oil to follow the rings.

Anti-friction bearings, on the other hand, can be lubricated either with oil or grease, according to the design of the bearing. As a general rule, oil is preferred where the bearing is capable of retaining the oil supply without leakage. Greases, on the other hand, furnish better seals against the entry of dust, dirt and moisture. For such service, resistance to moisture and oxidation is an important factor.

Other characteristics which a grease should possess when it is to be used for anti-friction bearing service involve:

1. Minimum tendency to separate in storage or during service in the bearing. With a properly prepared grease this should not occur even under moderate heating.
2. Maximum resistance to hardening or decomposition. This would lead to development of a residue of soap within the bearing, and soap has a comparatively low lubricating value.
3. There should also be no constituent contained in a grease which might lead to corrosion, pitting, or rusting of the bearing elements, nor should there be any component which might cause the lubricating film to become sticky or the grease to gum. This would cause the balls or rollers to stick in the raceways.

The above requirements are contingent upon the grade and quality of the oil and soap used in manufacture, also the method of preparation. They are assured by the integrity of the manufacturer. From a mechanical viewpoint, however, the consistency or body will be of chief interest. Frequently a comparatively light product will best meet the requirements, especially if it contains an oil of sufficiently low pour test. On the other hand, there are certain grades of heavier greases which, by virtue of their lubricating ability will serve the purpose equally well, and with but a minimum tendency to channel in the housings.



Courtesy of Link-Belt Company

Fig. 8—A view directly under the shovel boom on a Link-Belt crawler gas shovel. Circles indicate the pressure grease fittings. The lower frame gears are enclosed in substantial housings and run in oil.

GEARS, CHAINS AND WIRE ROPE

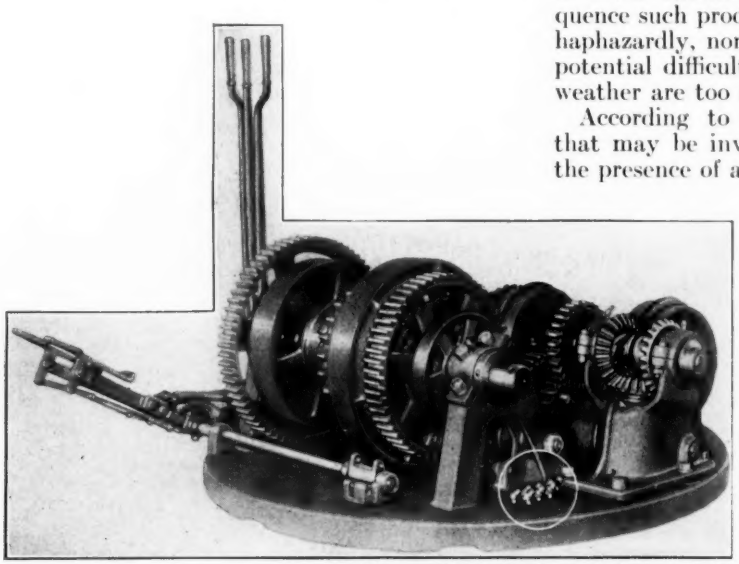
Any discussion of lubrication as it pertains to contracting machinery would be incomplete without consideration of those heavier, more massive parts which do the actual work in materials handling and which are so often exposed to the elements. It is fitting, therefore, to study the lubricating requirements of the wire rope which is so important in hoisting operations and the gears and chains which are employed in locating the shovel, drag or dipper with respect to the excavation or work to be handled.

Regardless of the efficiency of the power plant, the ultimate degree to which the machine as a whole will perform its intended function will depend upon the condition of its cables, wire ropes and reduction or power transmission gearing.

In other words, should a rope have one or two broken strands, due to insufficient or improper lubrication, it might very easily lead to a tie-up of the machine should the ends of the strands interfere with the operation of the sheaves. This might also involve a distinct hazard, for any wire rope in such condition is weak and more or less incapable of handling the loads to which it is subjected.

Wire Rope Design

Wire ropes usually come from the manufacturers in a lubricated state, being wound on an oil-saturated core. Under operation, however, there is constant friction and wear between the strands, and a tendency to squeeze out any contained lubricant, especially when the rope passes over sheaves or around drums. The renewal of this product, therefore, is an absolute necessity.



Courtesy of The Austin-Western Road Machinery Co.

Fig. 9—An Austin-Western Badger shovel turntable showing gearing and shifting levers. The bank of lubricators (circled) serve the track rollers and certain of the internal mechanisms.

Friction as developed between the strands of a wire rope is essentially the same as friction between a bearing and a shaft. Overheating and abnormal wear will practically always result, to reduce the load-carrying capacity and increase the amount of power consumed in operation. This can only be overcome by effective lubrication, brought about by the proper application, of a suitably prepared wire rope lubricant which will be capable of not only penetrating to the innermost strands and core of the rope, but also sufficiently adhesive and viscous to resist being prematurely squeezed out or washed off by rain or sleet.

The Most Suitable Lubricant

In addition to the above mentioned properties a wire rop lubricant, must not cake, gum, or ball up, especially if contaminated with an excess of dust, dirt or metallic particles. Furthermore, it must resist the thinning-down effects of higher temperature. This, of course, directly involves the viscosity or relative fluidity of the product. So the viscosity is the essential physical characteristic at the time of purchasing. It should not be assumed, however, as being the chief guide in regard to the ultimate suitability of a wire rope lubricant. The ability of the latter to function, penetrate and stick under actual operating conditions, is of more outstanding importance. In consequence such products should not be purchased haphazardly, nor on a price basis alone. The potential difficulties that might result in cold weather are too serious.

According to the operating temperatures that may be involved, and the possibility of the presence of an excess of water, the normal viscosity of a wire rope lubricant should range from 500 to 1000 seconds Saybolt at 210 degrees Fahr. Where there might be possibility of such a product thinning down to the extent of dripping off to perhaps result in lack of lubrication, it will be advisable to use a lubricant of approximately 1000 seconds viscosity, of course, in accordance with the prevailing temperature. Under relatively cold conditions, it is advisable to use a thinner product, but again in accordance with the range of operating temperatures involved.

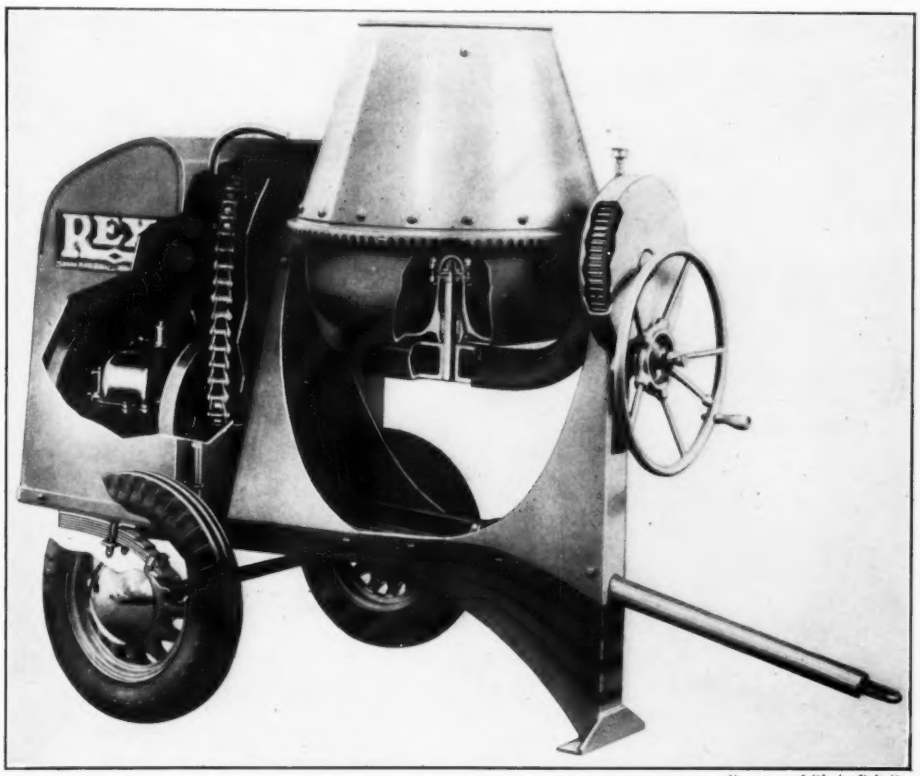
Wire rope lubricants should, in general, be straight mineral petroleum products, free from fillers or thickening mediums. In other words, whatever the viscosity, it should be an inherent property of the lubricant, not an artificial characteristic which cannot be depended upon.

This same property will often render such a lubricant so heavy as to require heating prior to application. To merely attempt to daub or paint a rope at normal temperatures is relatively ineffectual, for even though the surface might be more or less coated, the possibility of penetration occurring to any extent would be remote. This latter is the secret of effective wire rope lubrication. The amount of wear occurring between the exterior of such a rope and the sheaves is not as marked as that which occurs between adjacent strands when the rope is flexed or bent, as in passing over sheaves or hoisting drums. On the other hand, bending promotes penetration of the lubricant.

Gears

There is a considerable problem involved in the lubrication of power transmission and speed reduction gears on certain types of power shovels and excavating machines, due to the fact that they are usually exposed, or inadequately housed. There is, therefore, every

possibility of dust and dirt gaining entry, to increase the amount of wear and alter the pitch line. Pressure also requires consideration in such gear installations. As a general rule pressure will be comparatively high, due to the small areas of contact. The more accurately the gears have been cut the more intense will be the unit pressure, inasmuch as line contact will more nearly prevail.



Courtesy of Chain Belt Co.

Fig. 10—Cut-away of the Rex tilting concrete mixer showing grease chambers in the spindle and lubrication fittings at other points. Note also chain connections—another item requiring careful lubrication.

Gear tooth pressures change constantly as opposing teeth mesh with each other. This causes change in the direction of application of the load. As long as a rolling motion predominates, however, the effect on the structure of the teeth will not be serious. When wear occurs, however, there will be a tendency for the motion between the teeth to become sliding instead of rolling. This will give rise to a certain amount of grinding between the teeth, to cause wear, especially if lubrication is not maintained in an effective manner.

It is therefore essential that a gear lubricant possess sufficient oiliness to reduce friction to a minimum. This characteristic is dependent upon the viscosity and the ability of the lubricant to adhere to the teeth and resist the prevailing pressure.

Temperature will also affect this property, although in the normal operation of excavating machinery, gears will function at atmospheric temperature. As a result, there will be but little possibility of the gear lubricant being reduced in viscosity by abnormal heat.

The effect which low temperature may have upon a gear lubricant in service requires more consideration. Certain grades of lubricants will have a tendency to congeal to such an extent as to become brittle and crack. If a lubricant has been properly refined, however, there should be little danger of this occurring. Straight mineral lubricants will generally be best adapted to the prevailing operating conditions. The average range in viscosity for service on exposed gears will vary from approximately 500 to 1000 seconds Saybolt at 210 degrees Fahr., the higher viscosity being more nearly right to meet the usual requirements.

Where gears are enclosed, as is the practice in connection with transmission units or certain types of friction drive machines, the use of chain drives in certain of these installations will require a more fluid lubricant. It must be borne in mind that the average silent chain drive, as employed in this service will involve

comparatively low clearances between the connecting elements which go to make up the links. It is important, of course, that the lubricant be capable of penetrating to all surfaces of contact between these parts; otherwise, abnormal wear will take place. A lubricant of about the same viscosity as a heavy steam cylinder oil; i.e., in the neighborhood of 150 to 200 seconds Saybolt at 210 degrees Fahr., has proved satisfactory for such service.

Noise is the primary indication of wear in gears and driving chains. As a general rule, there will be more chance for ventilation than prevails with the average bearing. In consequence, increase in operating temperatures will usually not be as marked, even in extreme cases of faulty lubrication of gear teeth or chain link connections, for radiation will serve as an effective means of temperature reduction.

Furthermore, whereas it is often practicable to test the temperature of a bearing by hand, with a gear or chain, this practice would be hazardous, and even if possible would be no indication of the probable actual temperature at the wearing surfaces.

Development of noisy, clanking operation, however, is a decidedly positive indication that a gear or chain lubricant is not functioning as it should, in the prevention of metallic contact and solid friction.

It will be of interest to note that with gears especially there will be periods over which the lubricant will be inactive, for actual friction between the teeth will only occur when they are in mesh. To a somewhat less extent the load imposed upon a chain link connection will also be decreased over the period of slack operation.

Chain lubrication, on the whole, is akin to bearing lubrication as to the requirements which will be imposed upon the lubricants. There is, however, more chance for lubricant to be thrown off from a chain link than from the average bearing, for even though bearings may be themselves subject to rotary or reciprocating motion, this will not be as severe as the action of centrifugal force involved in a chain installation. The effect of centrifugal force must be especially considered in the lubrication of exposed or semi-enclosed chains. Centrifugal force will be greatest during the period of bending, as the chains pass over the sprockets. At such times any lubricant on the outside surface of a chain may be thrown off, although this will depend upon the adhesive ability of the lubricant and the peripheral or surface speed of the sprockets.

There are two primary steps which must normally be followed in the safeguarding of driving chain lubrication, viz.:

1. The selection of a lubricant of adequate viscosity and adhesive ability, commensurate with the manner of housing and the method of application, and
2. Application of this lubricant over the inner or more active wearing surfaces, in order to insure as complete penetration as possible to the link connections before the lubricant has a chance to work its way to the outside surface of the chain from which it may be thrown off.

Of course, these points will apply more strictly to the exposed or semi-enclosed chain drive, wherein there is but little or no provision for automatic lubrication. Where a driving chain is subject to a constant supply of lubricant as in the timing gear drive in some automotive engines, or those enclosed industrial chains which are fitted with oil pumps and suitable piping for circulation of oil from a base reservoir, maintenance of lubrication is normally positive, and only requiring of an adequate supply of properly refined lubricant.

A carefully designed housing is a most important feature in the safeguarding of lubrication of any chain. By virtue of link construction the wearing effect of abrasive foreign matter may rapidly become very serious. In fact, it is virtually impossible to offset this, however suitable the lubricant may be.

Entry of such dust, dirt or metallic particles as may lead to wear through contamination of the lubricant must therefore be prevented wherever possible. The oil-tight housing is the most practicable solution of this problem, and it should be used wherever operating conditions may be severe.

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